Vacuum-Assisted Vaginal Delivery

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Approximately 5% (1 in 20) of all deliveries in the United States are operative vaginal deliveries. The past 20 years have seen a progressive shift away from the use of forceps in favor of the vacuum extractor as the instrument of choice. This article reviews in detail the indications, contraindications, patient selection criteria, choice of instrument, and technique for vacuum-assisted vaginal delivery. The use of vacuum extraction at the time of cesarean delivery will also be discussed. With vacuum extraction becoming increasingly popular, it is important that obstetric care providers are aware of the maternal and neonatal risks associated with such deliveries and of the options available to effect a safe and expedient delivery.

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Operative vaginal delivery refers to the application of either forceps or a vacuum device to assist the mother in effecting vaginal delivery of a fetus. The incidence of operative vaginal delivery in the United States is currently estimated at around 5%, or approximately 1 in 20 deliveries,[1-4] although there are large geographic differences in the rates of operative vaginal delivery across the country.[2] The lowest rates of instrumental vaginal delivery (< 5%) are seen in the Northeast and the highest rates (20%-25%) are in the South.[2] Although the overall rate of operative vaginal delivery has been declining, the proportion of vacuum-assisted deliveries has been increasing and now accounts for almost 4 times the rate of forceps-assisted vaginal births.[2]

Historical Perspective

The first instrumental deliveries were performed to extract fetuses from women at high risk of dying due to prolonged or obstructed labor. In these cases, saving the mother's life took precedence over possible harm to the fetus. With the development of safer techniques for vaginal extraction, however, the focus of these procedures has changed dramatically and the major indications for operative vaginal delivery in modern obstetric practice are to safeguard the well-being of the fetus. Vacuum extraction was first described in 1705 by Dr. James Yonge, an English surgeon, several decades before the invention of the obstetric forceps. However, it did not gain widespread use until the 1950s, when it was popularized in a series of studies by the Swedish obstetrician Dr. Tage Malmström.[5] By the 1970s, the vacuum extractor had almost completely replaced forceps for assisted vaginal deliveries in most northern European countries, but its popularity in many English-speaking countries, including the United States and the United Kingdom, was limited. By 1992, however, the number of vacuum assisted deliveries surpassed the number of forceps deliveries in the United States, and by the year 2000 approximately 66% of operative vaginal deliveries were by vacuum.[6]

Vacuum extraction was first described in 1705 by Dr. James Yonge, an English surgeon, several decades before the invention of the obstetric forceps.

Indications

An operative vaginal delivery should only be performed if there is an appropriate indication. In 2000, The American College of Obstetricians and Gynecologists (ACOG) published guidelines on the use of operative vaginal delivery (both forceps and vacuum), which included a list of accepted indications for such procedures.[4] These are summarized in Table 1. It should be made clear that none of these indications are absolute because the option of cesarean delivery is always available.

Earlier data suggested that fetal morbidity was higher when the second stage of labor (defined as the time from full cervical dilatation to delivery of the fetus) exceeded 2 hours, irrespective of fetal testing. As such, obstetric care providers were encouraged to expedite delivery once the second stage of labor was noted to be prolonged (defined in Table 1).[4] More recent data collected after routine use of epidural analgesia, however, have disputed this assertion and have shown that continued expectant management of women with prolonged second stage of labor is a safe and reasonable option if fetal testing is reassuring.[4,7,8] As such, prolonged second stage of labor—although still an indication—should no longer be regarded as an absolute indication for operative delivery. The risks to the mother of a prolonged second stage of labor include severe perineal injury (defined as a third or fourth degree perineal laceration) and postpartum hemorrhage, and appear to be associated more strongly with obstetric instrumentation rather than the length of the second stage of labor.[9]

Suspected fetal compromise in the form of a nonreassuring fetal heart rate tracing is perhaps the most common and widely accepted indication for operative vaginal delivery, although the interpretation of fetal heart rate tracings is subjective and highly variable.[10] Women with contraindications to Valsalva manuever may benefit from elective operative vaginal delivery. This includes women with select cardiac or neurologic diseases, such as some women

Table 1
Indications for Vacuum-Assisted Vaginal Delivery

Indication	Definition
Prolonged second stage of labor	In nulliparous women, this is defined as lack of progress for 3 hours with regional anesthesia or 2 hours without anesthesia. In multiparous women, it refers to lack of progress for 2 hours with regional anesthesia or 1 hour without anesthesia.
Nonreassuring fetal testing	Suspicion of immediate or potential fetal compromise (nonreassuring fetal heart rate pattern, abruption) is an indication for operative vaginal delivery when an expeditious delivery can be readily accomplished.
Elective shortening of the second stage of labor	Vacuum can be used to electively shorten the second stage of labor if pushing is contraindicated because of maternal cardiovascular or neurologic disease.
Maternal exhaustion	Largely subjective and not well defined.

Data from The American College of Obstetricians and Gynecologists.[4]

with New York Heart Association (NYHA) class III/IV cardiac disease and uncorrected intracerebral vascular malformations. Operative vaginal delivery may also be required if there is inadequate maternal expulsive efforts, such as women with spinal cord injuries or neuromuscular diseases. Maternal exhaustion is another commonly used indicator for operative vaginal delivery, but is not well defined and is highly subjective. As such, providers should make every effort to avoid using this as the sole indication for operative vaginal delivery.

Contraindications

A number of clinical situations exist in which operative vaginal delivery should not be attempted because of the potential risks to the fetus (Table 2).[4] For example, an underlying fetal condition such as a documented bleeding diathesis or bone demineralizing disease will predispose the fetus to major injury including intraventricular hemorrhage and skull fracture and, as such, should be regarded as an absolute contraindication to operative vaginal delivery. Such deliveries should also not be attempted if the fetal vertex is not engaged in the maternal pelvis, if the cervix is incompletely dilated, if the fetal membranes are not ruptured, if the fetal position (defined as the relationship of a nominated site of the presenting part to a denominating location on the maternal pelvis) is not known, if there is suspected cephalopelvic disproportion, or if there is fetal malpresentation (such as breech, brow, or face presentation).[11] Vacuum-assisted vaginal delivery should not be performed prior to 34 weeks of gestation because of the risk of fetal intraventricular hemorrhage.[4] Prior scalp sampling or multiple attempts at fetal scalp electrode placement are also relative contraindications to vacuum extraction because these procedures may increase the risk of cephalohematoma or external bleeding from the scalp wound.[12-14]

Vacuum-assisted vaginal delivery should not be performed prior to 34 weeks of gestation because of the risk of fetal intraventricular hemorrhage.

There is no consensus regarding minimum and maximum estimated fetal weights that preclude operative vaginal delivery. Performance of an operative vaginal delivery in a fetus with suspected macrosomia is supported by ACOG,[4] but should be performed with caution given the possible increased risk of fetal injury[15] and of shoulder dystocia, especially when the second stage of labor is prolonged. Because of the risk of intraventricular hemorrhage, vacuum extraction is not recommended in fetuses with an estimated weight less than 2500 g (which corresponds to < 34 weeks of gestation).

Table 2
Contraindications for Vacuum-Assisted Vaginal Delivery

Absolute Contraindications

- Underlying fetal disorder
  - Fetal bleeding disorders (eg, hemophilia, alloimmune thrombocytopenia)
  - Fetal demineralizing diseases (eg, osteogenesis imperfecta)
- Failure to fulfill all the requirements for operative vaginal delivery
  - Incomplete dilatation of the cervix
  - Intact fetal membranes
  - Unengaged vertex
- Abnormalities of labor
  - Fetal malpresentation (eg, breech, transverse lie, brow, face)
  - Suspected cephalopelvic disproportion
- Estimated gestational age < 34 weeks or estimated fetal weight < 2500 g
- Failure to obtain informed consent from the patient

Relative Contraindications

- Suspected fetal macrosomia (defined as an estimated fetal weight of ≥ 4500 g)
- Uncertainty about fetal position
- Inadequate anesthesia
- Prior scalp sampling or multiple attempts at fetal scalp electrode placement

Data from The American College of Obstetricians and Gynecologists.[4]

Alternatives to Operative Vaginal Delivery

Informed consent (either verbal or written) is required prior to performing an operative vaginal delivery. Alternative management strategies should be discussed and will vary depending on the clinical circumstances and on the indication for the operative vaginal delivery. For example, if the indication is a prolonged second

stage of labor in the setting of reassuring fetal testing, alternatives to an operative vaginal delivery include continued expectant management, oxytocin augmentation, and cesarean delivery. Because existing data suggest that most women with a prolonged second stage will ultimately deliver vaginally and that a second stage exceeding 2 hours in duration does not adversely affect neonatal outcome,[4,7,8] continued expectant management is reasonable. Changes in maternal positioning, a reduction in neuraxial anesthesia, increased emotional support to the patient, and "laboring down" (delayed pushing) in the second stage have all been shown to increase the likelihood of a successful vaginal delivery.[16-20] If such conservative interventions fail to achieve a vaginal delivery, either an operative vaginal delivery or a cesarean delivery can be performed. If the patient does not meet criteria for an operative vaginal delivery or if the operator does not feel comfortable performing the procedure, then a cesarean delivery should be recommended.

Prerequisites for Operative Vaginal Delivery

A series of criteria all need to be fulfilled before an operative vaginal delivery can be attempted. These are summarized in Table 3.[21] The cervix should be fully dilated and the membranes ruptured. The head must be engaged in the maternal pelvis, meaning that the biparietal diameter must have passed through the pelvic inlet. This is best assessed on abdominal examination using the Leopold's maneuvers, although confirmation of fetal station (defined as the leading bony edge of the fetal presenting part relative to the maternal ischial spines) of more than 0/+5 on transvaginal examination can also be used to document engagement. A large fetus, excessive molding of the fetal skull bones, a deflexed attitude (extension) of the fetal head, and asynclitism (lateral flexion of the fetal head) can make it appear as though the vertex is engaged when the leading bony edge is actually above the level of the ischial spines. Fetal lie, presentation, and position should all be documented. The type of operative vaginal delivery is classified according to the station and the degree of rotation of the fetal head within the pelvis (Table 4).[22] If the position is unclear on clinical examination—which may be seen in upwards of 25% of cases in which operative vaginal delivery is being considered[23]—an intrapartum ultrasound can be done to confirm fetal position. Prior to attempting an operative vaginal delivery, clinical pelvimetry should be performed with documentation of adequate mid and outlet pelvic dimensions. The estimated fetal weight should also be documented.

Once the obstetric care provider has confirmed that the patient is an appropriate candidate for an operative vaginal delivery, informed consent

Table 3
Prerequisites for Operative Vaginal Delivery

Maternal Criteria	Fetal Criteria	Uteroplacental Criteria	Other Criteria
Adequate analgesia	Vertex presentation	Cervix fully dilated	An experienced operator who is fully acquainted with the use of the instrument
Patient in the lithotomy position	The fetal head must be engaged in the pelvis	Membranes ruptured	Ability to monitor fetal well-being continuously
Bladder empty	The position of the fetal head must be known with certainty	No placenta previa	The capability to perform an emergency cesarean delivery if required
Clinical pelvimetry must be adequate in dimension and size to facilitate an atraumatic delivery	The station of the fetal head must be ≥ 0/+5		
Verbal or written consent obtained	The estimated fetal weight must be documented (ideally 2500-4500 g)		
	The attitude of the fetal head and the presence of caput succedaneum and/or molding should be noted		

Data from Norwitz ER et al.[21]

Table 4
Classification of Operative Vaginal Deliveries

Type of Procedure	Criteria
Outlet	(1) Scalp is visible at the introitus without separating the labia
	(2) Fetal skull has reached the level of the pelvic floor
	(3) Sagittal suture is in the direct anteroposterior diameter or in the right or left occiput anterior or posterior position
	(4) Fetal head is at or on the perineum
	(5) Rotation is $\leq 45°$
Low	Leading point of the fetal skull (station) is station +2/+5 or more but has not as yet reached the pelvic floor
	(a) Rotation is $\leq 45°$
	(b) Rotation is $> 45°$
Midpelvic	The head is engaged in the pelvis but the presenting part is above +2 station
High	(Not included in this classification)

Adapted from The American College of Obstetricians and Gynecologists.[22]

should be obtained. This can be either verbal or written. Either way, the potential risks, benefits, and alternatives to operative vaginal delivery should be discussed, and the discussion should be clearly documented in the medical record.

Selection of Instrument: Forceps or Vacuum?

Selection of the appropriate instrument depends on both the clinical situation and the operator's level of comfort and experience with the specific instrument. Factors that need to be considered include the availability of the instrument in question, the degree of maternal analgesia, and an appreciation of the risks and benefits of each of the individual instruments.

Published data suggest that forceps deliveries are associated with more maternal morbidity, whereas vacuum devices cause more neonatal injury. For example, a meta-analysis of 10 clinical trials concluded that vacuum-assisted deliveries were associated with significantly less maternal trauma than forceps, including a lower rate of severe perineal injury (odds ratio [OR], 0.41; 95% confidence interval [CI], 0.33-0.50).[24] Indeed, the shift toward vacuum-assisted deliveries over forceps has led to a significant reduction in the incidence of severe perineal injuries in the mother over the last 10 years. In this meta-analysis, vacuum devices were also associated with a reduced need for general and regional anesthesia, and with less postpartum pain than forceps.[24] In contrast, this same review showed that forceps deliveries have a lower risk of scalp injury and cephalohematoma than vacuum.[24] Additional advantages of forceps are that they can be used safely in premature infants, they can be used to effect rotation of the fetal head (which is not true of vacuum), and they are less likely to detach from the fetal head. Although vacuum deliveries are more likely to fail, the overall cesarean delivery rate is still lower when the vacuum device is used rather than forceps. The reason for this is not entirely clear. It may have to do with patient selection or with the fact that, in years past, a failed vacuum delivery was typically followed by an attempted forceps delivery, whereas a failed forceps was more likely to be followed by a cesarean delivery.

Although the decision of which instrument to use is dependent in large part on the preference of the individual care provider, there are certain clinical situations where one instrument may be preferred over another. For example, delivery of an occiput-posterior vertex with molding is best effected using forceps, whereas a vacuum extraction would be the instrument of choice when performing an outlet procedure on an occiput-anterior vertex in a woman with minimal analgesia.

Selection of Instrument: Which Vacuum Cup?

Having decided to perform a vacuum extraction, the operator must decide which cup to use. The original vacuum device developed in the 1950s by the Swedish obstetrician Dr. Tage Malmström was a disc-shaped stainless steel cup attached to a metal chain for traction (Figure 1). Due to technical problems and lack of experience with this instrument, vacuum devices did not gain popularity in the United States until the introduction of the disposable cups in the 1980s. There are 2 main types of disposable cups, which can be made of plastic, polyethylene, or silicone. The *soft cup* is a pliable funnel- or bell-shaped cup, which is the most common type used in the United States (Figure 2A). The *rigid cup* is a firm mushroom-shaped cup (M cup) similar to the original metal disc-shaped cup, and is available in 3 sizes (40, 50, and 60) (Figure 2B). Commercially available suction cups are summarized in Table 5.[25]

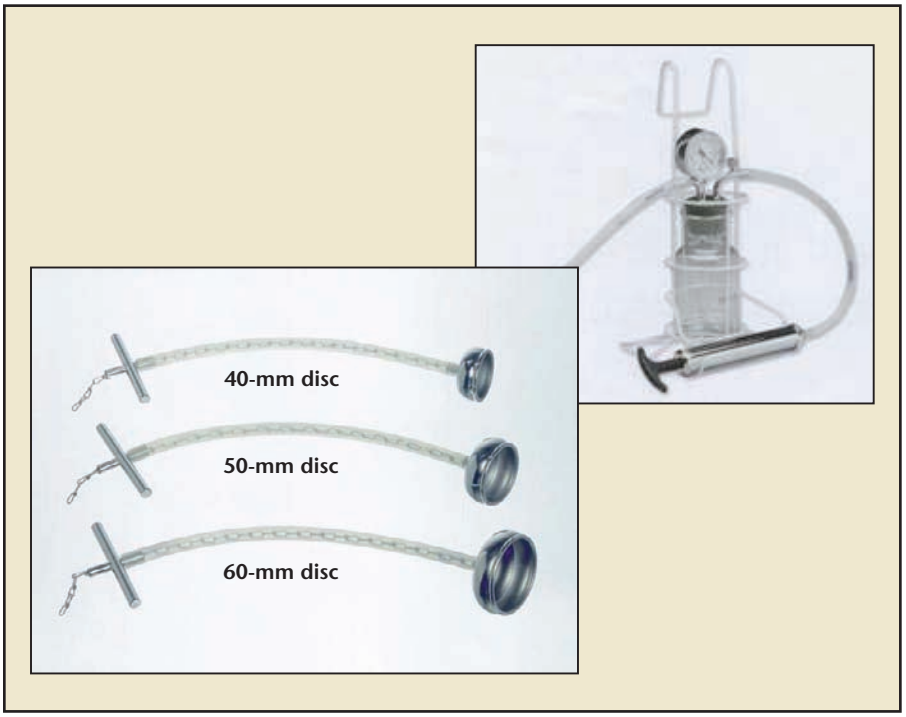


Figure 1. *Malmström ventouse. The original vacuum extractor developed in the 1950s by the Swedish obstetrician Dr. Tage Malmström is shown, including the metal mushroom cup (M cup), traction bar, and suction device.*

Figure 2. *Types of vacuum cups. The 2 main types of hand-held disposable vacuum devices are shown:* (A) *The soft cup, which is pliable and funnel- or bell-shaped.* (B) *The rigid cup, which is firm and mushroom-shaped (M cup). They can be made of plastic, polyethylene, or silicone. The freely rotating stem of the hand-held device (shown as an* arrow*) prevents torque (rotation) of the cup and resultant cookie-cutter injuries to the fetal scalp.*

By creating a mechanical as well as vacuum link, the rigid mushroom cup is able to generate more traction force than the soft cup. A meta-analysis of 1375 women in 9 trials comparing soft and rigid vacuum extractor cups demonstrated that soft cups were more likely to fail to achieve a vaginal delivery because of more frequent detachments (pop-offs) (OR, 1.65; 95% CI, 1.19-2.29), but were associated with fewer scalp injuries (OR, 0.45; 95% CI, 0.15-0.60) and no increased risk of maternal perineal injury.[26] By example, the risk of scalp laceration with the rigid Kiwi OmniCup® (Clinical Innovations, Murray, UT) was reported to be 14.1% compared with 4.5% utilizing a standard vacuum device ($P = .006$).[27] These and other authors[28-30] concluded that hand-held soft bell cups should be considered for more straightforward occiput-anterior deliveries, and that rigid M cups should be reserved for more complicated deliveries such as those involving larger infants, significant caput succedaneum (scalp edema), occiput-posterior presentation, or asynclitism. Three randomized trials have compared the standard vacuum cup to the Kiwi OmniCup device.[6,31,32] Failure rates for the Kiwi OmniCup were generally higher at 30% to 34% as compared with 19% to 21% for the standard vacuum device,[6,31] although not all studies confirmed this association.[32] The reason for the higher failure rate appears to be more frequent detachments.

Application and Technique

A successful vacuum-assisted vaginal delivery is dependent on several factors, including patient selection and a number of technical considerations. The goal is correct placement of the vacuum cup on the fetal scalp, application of a vacuum of up to 0.8 kg/cm^2 to suck part of the scalp into the cup and create an artificial caput succedaneum (known as a chignon), and then application of a traction force to the fetus in concert with uterine contractions to expedite delivery. The bladder should be emptied immediately prior to the procedure, and adequate analgesia should be provided. The maternal and fetal status should be assessed continuously throughout the delivery. Most importantly, the obstetric provider should be willing to abandon the procedure if there is no descent of the vertex or in the event of complications, and access to emergent cesarean delivery should be immediately available at all times.

Correct placement of the suction cup on the fetal scalp is critical to

Table 5
Types of Vacuum Suction-Cup Devices for Operative Vaginal Delivery

Device	Size	Material
Soft Cups		
Gentle Vac™ (OB Scientific, Germantown, WI)	60 mm	Soft rubber
Kiwi ProCup® (Clinical Innovations, Murray, UT)	65 mm	Soft plastic
Mityvac MitySoft Bell® (Cooper-Surgical, Trumball, CT)	60 mm	Soft silicone
Secure Cup™ (Utah Medical, Midvale, UT)	63 mm	Rubber
Silc Cup	50-60 mm	Silicone rubber
Soft Touch™ (Utah Medical)	60 mm	Soft polyethylene
Tender Touch® (Utah Medical)	60 mm	Soft silicone
Vac-U-Nate™ (Utah Medical)	65 mm	Soft silicone
Rigid Anterior Cups		
Flex Cup™ (Utah Medical)	60 mm	Polyurethane
Kiwi OmniCup® (Clinical Innovations)	50 mm	Rigid plastic
Malmström (Dickinson Healthcare, Hungerford, UK)	40-60 mm	Metal
Mityvac M-Style® (CooperSurgical)	50 mm	Rigid polyethylene
Rigid Posterior Cups		
Bird posterior cup	40-60 mm	Metal
Kiwi OmniCup® (Clinical Innovations)	50 mm	Rigid plastic
Mityvac M-Select® (CooperSurgical)	50 mm	Rigid polyethylene

Adapted from Greenberg JA.[25]

success of the procedure. The suction cup should be placed symmetrically astride the sagittal suture at the median flexion point (also known as the pivot point), which is 2-cm anterior to the posterior fontanelle or 6-cm posterior to the anterior fontanelle (Figure 3). Extreme care should be taken to avoid placement directly over the fontanelle. Correct placement will facilitate flexion, descent, and rotation of the vertex when traction is applied and will minimize injury to both the fetus and soft tissues of the birth canal. After the cup is applied, the circumference of the cup should be swept to ensure that no vaginal or cervical tissues have been inadvertently trapped within the vacuum cup. The placement of the cup on the scalp should be again confirmed. Suction can then be applied. Vacuum pressures should be raised initially to 100 to 150 mm Hg to maintain the cup's position before being increased further to facilitate traction.

In the past, a slow incremental increase in vacuum pressure was recommended before applying traction, starting at a negative pressure and increasing gradually at 0.2 kg/cm^2 every 2 minutes to achieve a pressure of approximately 0.8 kg/cm^2 (alternatively expressed as 500-600 mm Hg, 500-600 torr, 23.6 in Hg, or 11.6 lbs/in^2) within 8-10 minutes. The explanation given was that this slow incremental approach would allow for a more firm attachment of the vacuum cup to the fetal head and, thereby, a lower failure rate. However, there is no evidence that such an approach is associated with an improved rate of successful vaginal delivery. In fact, a randomized control trial of 94 women comparing stepwise versus rapid pressure application demonstrated that the rapid technique was associated with a significant reduction in the duration of vacuum extraction by an average of 6 minutes without adversely impacting fetal and maternal outcome.[33] A vacuum pressure of 0.6 to 0.8 kg/cm^2 (500-600 mm Hg) and an artificial caput succedaneum can be achieved in a linear, rapid fashion in less than 2 minutes.[34,35]

The absolute safe traction force for vacuum extraction is unknown. However, because traction force varies with cup size, suction pressure, and altitude as well as the individual clinical circumstances, it is reasonable and practical to rely on the suction pressure that is displayed on all the commercially available devices. Once the desired pressure has been achieved, sustained downward traction should be applied along the pelvic curve using 2 hands. The dominant hand exerts traction while the nondominant hand monitors the progress of descent and prevents cup detachment by applying counter pressure directly to the vacuum cup. The traction should be applied in concert with uterine contractions and maternal expulsive efforts. An observational study of 119 vacuum-assisted vaginal deliveries using a device with a traction force indicator revealed that a traction force of 11.5 kg (450 mm Hg) was sufficient to achieve vaginal delivery in at least

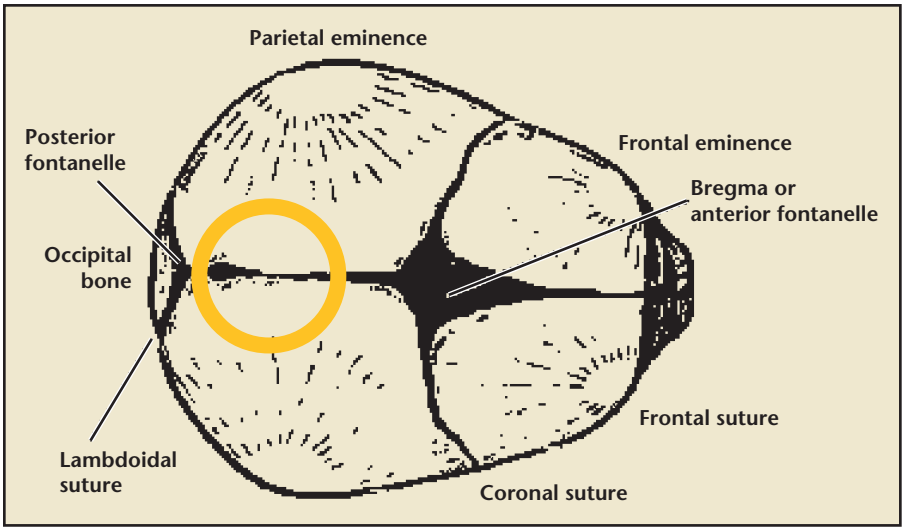


Figure 3. *Placement of the obstetric vacuum. Correct placement of the suction cup on the fetal scalp is shown. The suction cup should be placed symmetrically astride the sagittal suture at the median flexion point (also known as the pivot point), which is 2 cm anterior to the posterior fontanelle or 6 cm posterior to the anterior fontanelle.*

80% of cases. Moreover, all deliveries were achieved with a maximum traction force of 13.5 kg (500-600 mm Hg), although, at these higher levels, neonatal scalp abrasions and cephalohematomas were more common.[36] Traction should be discontinued when the contraction ends and the mother stops pushing. Between contractions, suction pressure can be maintained or reduced to lower than 200 mm Hg. There appears to be no difference in fetal morbidity with either regimen.[37] As it flexes and descends, the fetal head may rotate, resulting in passive rotation of the handle of the vacuum. Although this is to be expected, the accoucheur should at no time attempt to manually rotate the fetal head with the vacuum. This will lead to the classic cookie-cutter injury in the fetal scalp. Descent of the vertex should occur with each application of traction. Once the fetal head is seen to be crowning, the suction should be released, the cup removed, and the remainder of the delivery effected in the normal fashion.

The decision to continue with operative vaginal delivery must be re-evaluated continuously during each step of the delivery. The maximum time to safely complete a vacuum extraction and the acceptable number of detachments is unknown. In an observational study of 393 singleton term pregnancies, 82% of successful deliveries were achieved within 1 to 3 pulls, and more than 3 pulls was associated with a 45% risk of neonatal trauma.[38] Based on these and similar data,[39,40] it is generally recommended that vacuum-assisted deliveries be achieved with no more than 3 sets of pulls and a maximum of 2 to 3 cup detachments (pop-offs). The total vacuum application time should be limited to 20 to 30 minutes.[4] These recommendations are based more upon common sense and experience than scientific data as observational series have shown no long-term differences in neonatal outcome related to these variables.[25]

Reasons for Failed Vacuum Extraction

Vacuum-assisted vaginal deliveries may fail because of poor patient selection (such as attempting vacuum extraction in pregnancies complicated by cephalopelvic disproportion) or errors in application or technique. For example, selection of the incorrect cup size, accidental inclusion of maternal soft tissues within the cup, and/or incorrect placement of the vacuum cup, resulting in worsening asynclitism (lateral traction) or deflexion (extension) of the fetal head, may all contribute to failed vacuum attempts. Failure to apply traction in concert with maternal pushing efforts or traction along the incorrect plane may also result in failed vacuum extraction. To avoid fetal injury, the obstetric care provider should not be overly committed to achieving a vaginal delivery and should be willing to abandon the procedure if it is not progressing well. Delay may increase the risk of neonatal or maternal morbidity. The ability to perform an emergency cesarean delivery should always be at hand.

Maternal Complications

There is substantial evidence that instrumental deliveries increase maternal morbidity, including perineal pain at delivery, pain in the immediate postpartum period, perineal lacerations, hematomas, blood loss and anemia, urinary retention, and long-term problems with urinary and fecal incontinence. A randomized trial of 118 nulliparous term deliveries showed significant maternal soft tissue trauma in 48.9% of forceps deliveries, 36.1% of deliveries using the silastic vacuum extractor, and 21.6% of deliveries using the Mityvac® vacuum extractor (CooperSurgical, Trumball, CT) deliveries.[41] Another review of over 50,000 vaginal deliveries at the University of Miami reported that the rates of third and fourth degree perineal lacerations were higher in vacuum-assisted (10%) and forceps deliveries (20%) compared with spontaneous vaginal deliveries (2%).[42] The highest rates of maternal perineal trauma are associated with deliveries

involving rotations larger than 45° and with midforceps procedures.[43] The risk of maternal trauma is higher for fetuses in the occiput-posterior position.[44,45] For example, a retrospective cohort study of over 390 vacuum-assisted vaginal deliveries found that an occiput-posterior position was associated with a 4-fold increased risk of anal sphincter injury compared with an occiput-anterior position, which persisted after controlling for multiple covariables.[45]

Urinary and anal dysfunction (including incontinence, fistula formation, and pelvic organ prolapse) are additional risks of instrumental delivery that typically present months to years after delivery. A 5-year follow-up of a cohort of 228 women and children delivered by forceps or vacuum extractor as part of a previous randomized, controlled study reported that 47% experienced urinary incontinence, 44% reported bowel habit urgency, and 20% experienced loss of bowel control.[46] There were no apparent differences between the types of instruments used and no noninstrumental spontaneous delivery control group.

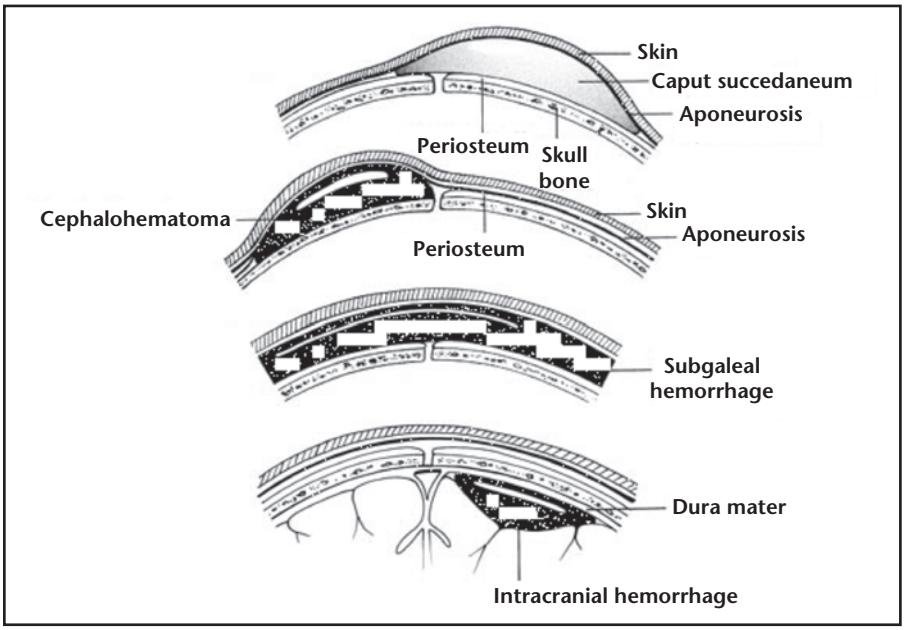
Maternal morbidity from instrumental deliveries is often compared with that of cesarean deliveries because this is the most likely alternative procedure. Compared with cesarean delivery, operative vaginal delivery is associated with less short-term maternal morbidity. In a retrospective review of 358 midcavity operative vaginal deliveries and 486 cesarean deliveries, febrile morbidity was significantly lower in women delivered vaginally (25% vs 4%) and all thromboembolic events occurred in women delivered by cesarean.[47] However, long-term data suggest that laboring women delivered with the use of obstetric instruments have a higher rate of urinary incontinence at 1 and 3 years postpartum compared with laboring women delivered by cesarean.[48,49]

Neonatal Complications

Vacuum-assisted vaginal deliveries can cause significant fetal morbidity, including scalp lacerations, cephalohematomas, subgaleal hematomas, intracranial hemorrhage, facial nerve palsies, hyperbilirubinemia, and retinal hemorrhage. The risk of such complications is estimated at around 5%.[50] Cephalohematomas, bleeding into the fetal scalp due to separation from the underlying structures (Figure 4), are more common with vacuum than with forceps deliveries (14%-16% vs 2%, respectively).[26,41] The incidence of subgaleal hematomas after vacuum-assisted vaginal delivery ranges from 26 to 45 per 1000 deliveries.[4] A cross-sectional study evaluating the incidence of neonatal retinal hemorrhage found that the incidence was higher for vacuum-assisted vaginal deliveries (75%) compared with spontaneous vaginal (33%) and cesarean deliveries (7%).[51] By far the most serious complication is intracranial hemorrhage. A California-based review of over 580,000 term singleton deliveries by Towner and colleagues[52] reported an incidence of intracranial hemorrhage of 1 in 860 for vacuum extraction compared with 1 in 1900 for women who delivered spontaneously. The incidence was the highest (1 in 280) in women delivered by combined forceps and vacuum-assisted vaginal deliveries.[52]

Pediatricians should be notified whenever an operative vaginal delivery has been attempted and whether it was successful because serious morbidity can present several hours after birth. For this reason, such neonates should be closely observed. A large prospective, observational, cohort study conducted in the Netherlands found that

Figure 4. *Fetal scalp injuries associated with vacuum extraction. Caput succedaneum (scalp edema) is a normal finding, but may be exaggerated by vacuum-assisted delivery. Use of a vacuum device can cause a cephalohematoma (which refers to bleeding into the fetal scalp that is located in the subperiosteal space and, as such, is contained anatomically to a single skull bone) or a subgaleal hematoma (bleeding into the fetal scalp which is subaponeurotic and therefore not confined to a single skull bone). The most serious complication is an intracranial hemorrhage, which includes subarachnoid, subdural, intraparenchymal, and intraventricular hemorrhage.*



all vacuum-related injuries in term neonates were evident within 10 hours of birth. The authors concluded that neonates may be discharged 10 or more hours after vacuum delivery if no complications are evident.[53]

In 1998, the United States Food and Drug Administration (FDA) issued a public health advisory to inform individuals that fetal complications including subgaleal hematomas and intracranial hemorrhage had been associated with vacuum extraction.[54,55] In support of their assertion, the FDA identified 12 deaths and 9 serious complications reported among infants exposed to vacuum-assisted devices between 1994 and 1998, a rate that was 5-fold higher than that reported in the previous 11 years. The FDA advised caution and offered a series of recommendations for the appropriate and safe use of vacuum extractor devices. Specifically, they recommended that operators refrain from rocking movements and from the application of torque (rotation). They advised instead that providers use "steady traction in the line of the birth canal."[54] They also stressed the importance of notifying pediatricians that a vacuum device had been applied so that the neonates could be monitored more closely during the first hours and days of life.

Long-term sequelae from vacuum-associated injuries such as intracranial hemorrhage and neuromuscular injury are uncommon. For example, a 9-month follow-up study of children randomized at term to vacuum versus forceps delivery found no significant differences in head circumference, weight, head circumference-to-weight ratio, testing of vision and hearing, and hospital readmission rates.[56] Vacuum-assisted vaginal delivery also does not appear to adversely impact long-term cognitive development. A 10-year follow-up evaluation of 295 children delivered at term by vacuum extraction and 302 control patients delivered by spontaneous vaginal delivery showed no differences in fine- and gross-motor control, perceptual integration, and behavioral maturity between the 2 groups.[57]

Neonates may be discharged 10 or more hours after vacuum delivery if no complications are evident.

Clinical Controversies

A number of clinical controversies still surround vacuum-assisted vaginal delivery. These are discussed briefly below.

Sequential Attempts at Instrumental Vaginal Delivery

ACOG does not generally support multiple attempts at vaginal delivery using different instruments because of concerns about a higher rate of maternal and neonatal injury.[4,52] Initial small clinical studies failed to demonstrate any adverse effects from combined or sequential vacuum and forceps deliveries, but larger studies suggest otherwise.[58,59] The previously mentioned study by Towner and colleagues[52] reviewed the mode of delivery and subsequent perinatal morbidity in 583,340 nulliparous term infants weighing 2500 g to 4000 g born in California between 1992 and 1994. The authors reported that the incidence of intracranial (subarachnoid, subdural, intraparenchymal, and/or intraventricular) hemorrhage was highest in infants delivered by both vacuum and forceps (1 in 256) as compared with infants born by forceps (1 in 664) or vacuum extraction alone (1 in 860), cesarean delivery in labor (1 in 907), spontaneous vaginal delivery (1 in 1900), and elective cesarean delivery prior to labor (1 in 2705). A similar study by Gardella and colleagues[60] used Washington state birth certificate data linked to hospital discharge records to compare perinatal outcome in 3741 vaginal deliveries by both vacuum and forceps, 3741 vacuum deliveries, 3741 forceps deliveries, and 11,223 spontaneous vaginal deliveries. The study found that the sequential use of vacuum and forceps was associated with significantly increased risk of both neonatal and maternal injury.[60]

Not all cases of intracranial hemorrhage are symptomatic. A prospective study on 111 asymptomatic term infants who underwent routine magnetic resonance imaging shortly after delivery found that infants delivered after a failed vacuum extraction were the most likely to have a subdural hemorrhage with a rate of approximately 28% versus 6% after spontaneous vaginal delivery and 8% after a successful vacuum delivery.[61]

Routine Use of Antibiotics at the Time of Assisted Vaginal Delivery

There is insufficient evidence to support the routine administration of antibiotic prophylaxis during assisted vaginal deliveries to prevent postpartum infection. A retrospective review of 393 women compared the rates of endomyometritis among women delivered by vacuum or forceps, and found no statistical difference in the rates of infection or the length of hospitalization among those who received prophylactic antibiotics and those who did not.[62] As such, the routine use of antibiotic prophylaxis at the time of operative vaginal delivery cannot be recommended.

Use of Episiotomy at the Time of Assisted Vaginal Delivery

Episiotomy refers to a surgical incision in the perineum designed to enlarge the vagina and assist in childbirth. Although episiotomy has often accompanied operative vaginal

delivery, recent evidence suggests that routine use of episiotomy with vacuum extraction is associated with an increased rather than decreased risk of perineal trauma and rectal injuries.[63,64] Episiotomy during operative vaginal delivery also increases the incidence of postpartum hemorrhage and perineal infection, the need for stronger analgesia, and neonatal birth trauma.[63] Moreover, pressure exerted by the soft tissues of the pelvic floor promotes flexion and rotation of the fetal head as it descends through the birth canal, which will not be possible if these tissues have been surgically transected. Taken together, these data suggest that routine episiotomy during vacuum extraction should be discouraged.

Routine Use of Vacuum Extraction During Cesarean Delivery

Vacuum devices can be used at the time of cesarean delivery to effect delivery of a high unengaged fetal head or as an alternative to extension of the hysterotomy when delivery of the vertex is difficult. Once the head is visible through the uterine incision, the vacuum device can be applied directly to the vertex and delivery achieved with gentle upward traction in concert with fundal pressure. Although such an approach may reduce the risk of extension of the original hysterotomy, it is not recommended for all cesarean deliveries.

With appropriate training and careful patient selection, vacuum-assisted vaginal delivery can be a valuable tool in the armamentarium of the practicing obstetric care provider to effect delivery of an at-risk fetus.

Conclusions

Approximately 5% (1 in 20) of all deliveries in the United States are operative vaginal deliveries. There is an increasing trend toward the use of vacuum devices rather than forceps for such procedures due, at least in part, to mounting data suggesting that vacuum extraction is associated with less maternal morbidity. To safely perform a vacuum delivery, it is important that the operator understand the indications and contraindications for this procedure. As a general rule, the soft (bell-shaped) cups should be used for uncomplicated occiput-anterior deliveries, whereas the rigid M cups should be reserved for more complicated deliveries such as those involving larger infants, significant caput succedaneum, occiput-posterior position, or asynclitism. Informed patient consent must be obtained. With appropriate training and careful patient selection, vacuum-assisted vaginal delivery can be a valuable tool in the armamentarium of the practicing obstetric care provider to effect delivery of an at-risk fetus. In all instances, the potential risks and benefits of a vacuum-assisted delivery must be weighed against the available alternative, including continued expectant management, oxytocin augmentation, and cesarean delivery. ■

Main Points

- An operative vaginal delivery should only be performed if there is an appropriate indication. No indication is absolute because the option of cesarean delivery is always available.
- A number of clinical situations exist in which operative vaginal delivery should not be attempted because of the potential risks to the fetus.
- A series of criteria all need to be fulfilled before an operative vaginal delivery can be attempted.
- Selection of the appropriate instrument depends on both the clinical situation and the operator's level of comfort and experience with the specific instrument.
- Soft bell-shaped cups are associated with fewer scalp injuries and no increased risk of maternal perineal injury.
- Soft bell-shaped cups should be considered for straightforward occiput-anterior deliveries and rigid M cups should be reserved for more complicated deliveries.
- A successful vacuum-assisted vaginal delivery is dependent on several factors, including patient selection and a number of technical considerations. The goal is correct placement of the vacuum cup on the fetal scalp, application of a vacuum of up to 0.8 kg/cm^2 to suck part of the scalp into the cup and create an artificial caput succedaneum (known as a chignon), and then application of a traction force to the fetus in concert with uterine contractions to expedite delivery.
- There is evidence that instrumental deliveries increase maternal morbidity. The risk of maternal injury is much higher with forceps compared with vacuum-assist devices.
- Vacuum-assisted vaginal deliveries can cause significant fetal morbidity. Pediatricians should be notified whenever an operative vaginal delivery has been attempted.

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